Operating Experience Weekly Summary 97-44

October 24 through October 30, 1997

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EVENTS

1. SUBCONTRACTORS BURNED FROM ELECTRICAL FLASHOVER

On October 22, 1997, at FERMI National Accelerator Laboratory, two subcontractor electrical workers installing a temporary feed from a 480-volt motor control center panel received burns when a metal cover contacted an energized bus. Fire department personnel responded to the scene. They sent one subcontractor to a local hospital by ambulance. He was later transferred to a facility with a burn unit, where he was treated for burns to his hands and immediately released. The second subcontractor was transported by helicopter directly to a facility with a burn unit. He was treated for burns to his face and hands and released from the hospital 6 days later. DOE assembled a Type B accident investigation team to review this event. OEAF engineers will follow the investigation and provide lessons learned in a future Weekly Summary. (ORPS Report CH-BA-FNAL-FERMILAB-1997-0004)

KEYWORDS: electrical, work control, injury

FUNCTIONAL AREAS: Industrial Safety, Configuration Management, Hazards Analysis, Work Control

2. OPEN REACTOR CONFINEMENT PENETRATIONS AT IDAHO

On October 25, 1997, at the Idaho National Engineering Environmental Laboratory Advanced Test Reactor Facility, an operator noticed five, open 1.5-inch pipes penetrating the gas-tight reactor confinement boundary. The operator immediately reported his discovery to the shift supervisor. The shift supervisor determined that a technical specification action statement had been entered inadvertently. This required either sealing open penetrations resulting in an area greater than 7 square inches or manually shutting down the reactor within 24 hours. Investigators later determined that eight spiral discharge nozzles were installed in the piping. This limited the total cross-sectional area to 3.53 square inches. Investigators determined that current facility work controls permitted the removal of halon piping during reactor operation without ensuring that the penetrations were resealed. Administrative controls requiring authorization and planning before installing modifications failed to prevent this occurrence and could have resulted in a technical specification violation. (ORPS Report ID--LITC-ATR-1997-0021)

The operator was performing a walk-down of modifications made by a construction subcontractor when he noticed the open penetrations. The subcontractor had removed the halon system distribution piping connecting halon gas supply bottles outside the reactor building to eight spiral discharge nozzles inside the building. When the operator saw the open piping he knew that the spiral discharge nozzles were open inside the confinement area, breaching the reactor gas-tight confinement boundary. Maintaining a gas-tight confinement, within the allowable leakage limits specified in the technical specifications, reduces the radiological release consequences in the event of an accident.

Investigators determined that the subcontractor did not obtain or use the gas-tight penetration approval form required for the piping removal. The facility manager held a critique to determine how the work control process had failed. Critique members learned that the work package for removing the piping included instructions for installing permanent seals, but had no instructions for sealing the penetrations temporarily. They also determined that the work package did not specify that open penetrations could constitute a technical specification violation. Critique members learned that the required personnel, including operations personnel, reviewed the work package before it was approved. In addition, the operations shift supervisor walked down the job with the subcontractor before the job began. However, the supervisor failed to recognize that the pipe removal would result in open penetrations.

A similar event occurred on December 16, 1996, when a subcontractor removed a temporary seal from a reactor confinement penetration without shift supervisor approval and without submitting a gas-tight penetration approval form. The facility manager determined that the following errors contributed to this event. (ORPS Report ID--LITC-ATR-1996-0031)

- The shift supervisor did not discuss the required approval forms for removing gas-tight penetrations with the subcontractor during the pre-job brief. He also was not aware that it was the subcontractor's first day on the job, so he conducted a "broad-based" pre-job briefing.

- Construction engineering staff did not thoroughly document daily activities for maintenance craft personnel. Therefore, operation and maintenance personnel who approve or oversee maintenance jobs did not always understand the details well enough to prevent errors.

- The subcontractor noticed caution tags on the piping that prohibited seal removal, but believed that the shift supervisor had given him authorization to proceed. He was not aware of the requirement to process a gas-tight penetration approval form before he began work.

Corrective actions for the December 16 event included (1) training subcontractor personnel on the requirement for using the penetration approval form and providing instructions on how to respond to caution tags, (2) evaluating the construction work control process, and (3) incorporating identified deficiencies into the appropriate work control documents. However, these corrective actions failed to prevent recurrence.

NFS has reported inadequate work control events in several Weekly Summaries. Following are some examples.

- Weekly Summary 97-02 reported that the DOE Office of Enforcement and Investigation issued a Preliminary Notice of Violation under the Price-Anderson Amendments Act to the Los Alamos National Laboratory for unauthorized modification of tritium monitors. A second issue concerning a modification to install a building sump was also addressed in the notice letter. The Office of Enforcement and Investigation conducted an on-site review of these issues and concluded that violations of the Quality Assurance Rule (10 CFR 830.120) probably occurred. The violations represented weaknesses in design control, work control, and quality improvement. [NTS Report NTS-ALO-LA-LANL-TSF-1996-0001; letter, DOE (T. O'Toole) to Los Alamos National Laboratory (S. Hecker), 12/18/96]

- Weekly Summary 97-03 reported that a building manager at the Rocky Flats Environmental Technology Site found several external electric circuit breaker operators (handles) that had been replaced without authorization or the required planning and coordination with other building activities. Investigators found no authorization to perform the work and determined that written procedures for the work were not available or not used. (ORPS Report RFO--KHLL-NONPUOPS1-1997-0002)

These events underscore the importance of four critical work control elements: (1) pre-job briefings and clear work control procedures for implementing maintenance work; (2) communication between work planners and working groups to ensure that activities are specifically identified in work packages and appropriate limits are defined; (3) proper implementation of corrective actions; and (4) the necessity for facility managers to ensure that contractors understand and follow work control programs. Proposed modifications to a system need to be thoroughly reviewed, and the impact of other systems on the design basis should be evaluated. If the corrective actions from the December 16 event had been correctly determined and properly implemented, the latest event may not have occurred. Also, the contractor believed he was following the work control program because no one informed him of the requirement to obtain a gas-tight penetration approval form. This is an indication that facility management failed to adequately communicate work control mechanisms and their importance to the contractor. Facility managers are ultimately responsible for ensuring successful completion of work activities. Routine monitoring of contractor and subcontractor work by facility managers and supervisors will help ensure that maintenance activities are conducted in accordance with facility policy and procedures.

Many DOE Orders, standards, and guidelines addressing work control programs, training, conduct of operations, installations, independent verifications, and the adequacy of technical staff are applicable to this event. Facility personnel responsible for work that is performed by maintenance or contractor personnel should clearly understand their responsibilities. Facility managers should ensure that work controls are rigorous enough to allow workers to complete jobs safely and efficiently without relying solely on communications. Facility personnel responsible for corrective action programs should ensure that corrective actions are effective in preventing recurrence.

- DOE O 4330.4B, *Maintenance Management Program,* chapter 15, “Management Involvement,” identifies the degree of management involvement in oversight and approval of maintenance activities. Chapter II, section 8.3.1, “Work Control Procedure,” states that work control procedures help personnel understand the necessary requirements and controls. Section 8.3.6, “Control of Non-facility Contractor and Subcontractor Personnel,” states that contractor and subcontractor personnel who perform maintenance or modifications on facility systems should be trained and qualified for the work they are to perform. This section also states that contractor and subcontractor personnel should receive training on (1) facility administration, (2) safety, (3) quality control, (4) radiation protection procedures and practices, and (5) general employee training.

- DOE-STD-1004-92, *Root Cause Analysis Guidance Document,* chapter 6, “Corrective Actions,” states that proposed corrective actions should be (1) reviewed to ensure the appropriate criteria is met, (2) prioritized based on importance, (3) scheduled, (4) entered into a commitment tracking system, and (5) implemented in a timely manner. It states that a complete corrective action program should be based on specific causes of the occurrence, lessons learned from other facilities, appraisals, and employee suggestions. It also states that a successful program requires management involvement at the appropriate level and willingness to take responsibility and allocate adequate resources for corrective actions. Chapter 8, “Follow-Up,” provides information on following up on corrective actions to determine if they have been effective in resolving problems. It states that corrective actions should be tracked to ensure they have been properly implemented and are functioning as intended. It also states that the recurrence of the same or similar events must be identified and analyzed and, if the same or similar event recurs, the original occurrence should be investigated to determine why corrective actions were not effective.

- DOE-STD-1050-93, *Guideline to Good Practices for Planning, Scheduling and Coordination of Maintenance at DOE Nuclear Facilities*, section 3.1.1.3, provides the key elements of an effective planning program. Included is guidance on consistency in planning between disciplines to avoid confusion and frustration in work groups. The standard also discusses the need for thorough reviews of work packages by experienced individuals to eliminate errors.

- DOE-STD-1051-93, *Guideline to Good Practices for Maintenance Organization and Administration at DOE Nuclear Facilities*, section 2.3.8, “Non-Facility Personnel,” states that when non-facility personnel are used, the duties, authorities, responsibilities, and functional interfaces with personnel should be clearly defined. Section 4.3.4, “Management Control of Plant Configuration,” provides guidance to ensure plant configuration is maintained and conforms to established design bases.

KEYWORDS: halon, piping, work controls, containment

FUNCTIONAL AREAS: Work Planning, Licensing/Compliance, Lessons Learned

3. CONSTRUCTION WORKER RECEIVES ELECTRIC SHOCK

On October 23, 1997, at the West Valley Site, a construction worker received an electric shock while using power tools to perform work outdoors during wet weather. He picked up an extension cord by its connector, received a shock, and was temporarily unable to release the cord. The worker wore leather gloves that had become damp because of wet weather. Investigators believe that his gloves contacted the tines of the plug, which was connected to a circular saw, when he picked up the extension cord. They also determined that a ground-fault circuit interrupter was installed, but it failed. Failure of the ground-fault circuit interrupter and wet leather gloves resulted in the worker being shocked. (ORPS Report OH-WV-WVNS-WVNSGEN-1997-0003)

Investigators determined that the extension cord was plugged into a circular saw at one end and a 5,000-watt generator at the other. Electricians successfully tested the generator outlet’s factory-installed, ground-fault circuit interrupter that morning. After the construction worker received the shock, an electrician re-tested the circuit interrupter, determined that it was not functioning, and immediately replaced it. Investigators are continuing to determine why the ground-fault circuit interrupter failed and are developing corrective actions.

NFS has reported electrical events in numerous Weekly Summaries. Following are some examples.

- Weekly Summary 97-14 reported that an engineer at the Stanford Linear Accelerator Laboratory received a shock when he contacted a charged capacitor while attaching a test probe inside a high-voltage cabinet. Investigators determined the engineer did not use a grounding hook to ground the capacitors and was not wearing personal protective equipment. Investigators determined that inattention to detail and failure to use proper safety procedures resulted in an electric shock. (ORPS Report SAN--SU-SLAC-1997-0005)

- Weekly Summary 97-04 reported that an electrician at Hanford received minor flash burns when he reconnected energized, 480-volt power leads to a motor control center main breaker. The electrician and a co-worker believed the circuit was de-energized based on their interpretation of electrical system drawings and an earlier zero energy verification. The electrician received only minor burns because he was wearing the required protective clothing. (ORPS Report RL--PHMC-S&W-1997-0001)

- Weekly Summary 96-51 reported that a technician at Sandia National Laboratory received an electrical shock when his right hand came close to a high-voltage bank of capacitors. The network contained 14 capacitors connected in parallel to create a 4,200-volt potential. The discharge path through his body was from the bottom of his right wrist to his elbow at the point where it was in contact with the grounded metal chassis. (ORPS Report ALO-KO-SNL-14000-1996-0004)

OEAF engineers reviewed selected electrical occurrences from the ORPS database from October 1, 1990 through September 30, 1997, for reports that resulted in electrical shocks without any injuries and found 168 reports. We compared the number of shocks caused by voltages in various ranges to the total number of electrical occurrences in the same range. We determined that significantly more electrical shocks resulted from voltage ranges with alternating current at 120-volts or below, and near 1,000-volts of direct current. Figure 3-1 shows the voltage distribution for electrical shocks.

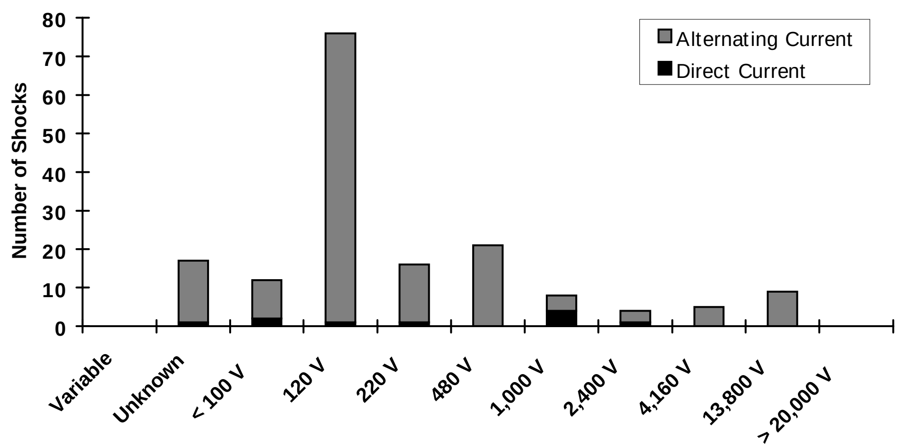

Figure 3-1. Voltages Involved in Electrical Injuries[1]

This event underscores the importance of wearing personnel protective equipment to provide multiple levels of protection. This event also illustrates the potential dangers involved in construction activities and the use of power tools. These activities may not always be performed in ideal weather or locations. Shocks are one of the frequent and serious effects that can occur when personnel become complacent to electrical hazards. Table 3-1 shows the expected effects of currents on humans. In addition, the U.S. Department of Labor, "*Analysis of Construction Fatalities – The OSHA Data Base 1985 – 1989,*" November 1990, states that 17 percent of construction fatalities were from electrical shocks. The OSHA publication also states that hand-held tools and electrical cords contributed to 52 fatalities from 1985 to 1989, representing 9 percent of total construction fatalities. *Type A Accident Investigation Board Report of the April 25, 1997, Contractor Fatality on the Olympia-White River #1 230-kV Line*, Appendix E, states that effects of electricity on the body are dependent on (1) the amount of current and the length of time the body is exposed to it, and (2) the path it takes through the body. In also states that the effect of the electricity depends on: (1) skin condition, (2) the area of the skin exposed to the electrical source, and (3) the pressure of the body against the source. The severity of shocks increases if the point of skin contact is moist or broken.

To prevent these injuries, protective equipment should be worn that is appropriate to the activity and the environmental conditions. Safety and health hazard analyses must be included in the work control process to help prevent worker injury. In addition, failure of the ground-fault circuit interrupters could be an indicator of poor electrical practices (such as inadequate testing criteria)

[1] This data was developed based on 742 occurrences. OEAF engineers reviewed these occurrences and found 168 reported shocks.

or equipment aging problems. However, the ground-fault circuit interrupter should not have been the only safety barrier in place.

Amount of current	Effect on a human
1 milliamp	Can just be felt
5 to 9 milliamps	Cannot let go
20 to 50 milliamps	Increasing pain
Above 50 milliamps	May be fatal

Table 3-1. Current Effects on Humans[1]

Facility managers should review contractor safety guidelines to ensure compliance with facility safety manuals and that workers wear the proper personnel protective equipment. They should also review safety guidelines to ensure that the failure of a single safety barrier will not put workers lives at risk.

- DOE 4330.4B, *Maintenance Management Program*, section 8.3.1, provides guidelines on work control systems and procedures. The Order states that work control procedures help personnel understand the necessary requirements and controls.

- OSHA regulations in 29 CFR 1926.416, sub-part K, *Electrical – Safety-Related Work Practices*, state that employees' hands may not be wet when handling flexible cords and cord and plug-connected equipment. It also states that plugs and electrical connections may be handled only with insulating protective equipment if the condition could provide a conducting path to the employee's hand.

- DOE/ID-10600, *Electrical Safety Guidelines*, prescribes safety standards for DOE field offices and facilities involved in the use of electrical energy. Included in the guidelines is information on training and qualifications, work practices, protective equipment, insulated tools, and recognition of electrical hazards.

- The National Fire Protection Association, *1996 National Electrical Code Handbook*, article 410-57, "Receptacles in Damp or Wet Locations," states that a receptacle installed in a wet location shall be in a weatherproof area and that the integrity cannot be affected when the attachment plug cap is inserted. It also states: "an enclosure that is not weatherproof when an attachment plug cap is inserted shall be permitted where a receptacle is installed in a wet location for use with portable tools or other portable equipment normally connected to the outlet only when attended."

KEYWORDS: electrical, work control, shock

FUNCTIONAL AREAS: Industrial Safety, Configuration Management, Hazards Analysis, Work Control

4. PIPEFITTER FALLS THROUGH ROOF PENETRATION

[1] Type A Accident Investigation Board Report of the April 25, 1997 Contractor Fatality on the Olympia-White River #1 230- kV Line, June 1997.

On October 22, 1997, at the Oak Ridge National Laboratory, a subcontractor pipefitter fell through a roof opening of a tank vault building and landed on wooden scaffold decking 15 feet below. Oak Ridge medical professionals checked the worker at the job site and determined that his injuries were not serious. They transported the pipefitter to a local medical facility where he was examined and released with work restrictions. As the pipefitter walked on a temporary plywood cover for a hatch into the tank vault, it somehow dislodged, allowing the pipefitter to fall. The construction manager suspended work on top of the tank vault, as well as all work above 6 feet for this project. Proper use of fall protection equipment can prevent a possible fatality or injuries. (ORPS Report ORO--LMES-X10CM-1997-0005)

Investigators reported that the pipefitter was sorting out piping on the roof of the building. He walked toward the stack of pipe and stepped onto the ¾-inch-thick plywood cover over a 45-inch by 45-inch opening in the roof. After looking through the stack of pipe, he turned, stepped back onto the plywood cover, and fell through the roof opening. The pipefitter was fortunate that the scaffolding broke his fall because the tank vault is 30 feet deep. The plywood cover was cut to sit in a recess in the hatch opening, but it was not fastened in place or marked to warn of the hazard.

The operating and maintenance contractor is conducting a Type C investigation of this event. Investigators have not determined why the plywood cover failed to prevent the fall, but they did determine that the cover had flipped over. The construction manager initiated an assessment of fall protection measures at other active on-site projects.

NFS has reported numerous fall protection violations and fall-related injuries in the Weekly Summary. Following are some examples.

- Weekly Summary 97-42 reported that a safety inspector at the Los Alamos National Laboratory initiated a stop work order to a roofing subcontractor because of repeated fall protection violations. The safety inspector observed a subcontractor safety monitor assisting in roofing activities. OSHA regulations and contractor procedures required using a dedicated safety monitor who had no other responsibilities. (ORPS Report ALO-LA-LANL-LANL-1997-0002)

- Weekly Summary 96-29 reported that a subcontractor employee escaped injury when his retractable lanyard activated as he fell 65 feet through the roof of a four-story building that was being demolished at Fernald. The employee lost his footing and fell forward onto an area where a layer of roof panels had been removed. His weight caused the remaining panel to give way, and he fell. The employee was wearing a full-body safety harness with a retractable lanyard that tightened and stopped his fall after 6 to 8 feet. (ORPS Report OH-FN-FERM-FEMP-1996-0038)

- Weekly Summaries 96-27 and 96-08 reported a fatal fall at the Idaho National Engineering Laboratory. A subcontractor project engineer, who was not wearing fall protection, fell 17 feet from a temporary platform. The engineer suffered severe head and neck injuries and died. The temporary platform had no guardrails, toeboards, or other fall protection. The Office of Environment, Safety and Health issued a Type A Accident Investigation Board Report that stated that hazards were not identified and there were no barriers in place to prevent the accident. (INEL Lessons Learned #96116, OEWS 96-08, *Type A Accident Investigation Board Report on the February 20, 1996, Fall Fatality at the Radioactive Waste Management Complex Transuranic Storage Area - Retrieval Enclosure*, ORPS Report ID--LITC-RWMC-1996-0001)

The Office of Environment, Safety and Health addressed fall protection in Safety & Health Note, DOE/EH-0489, Issue 95-3, "New OSHA Booklet on Fall Protection in Construction." This booklet provides a generic overview of fall protection. The booklet states: "In the construction industry in the U.S., falls are the leading cause of worker fatalities. Each year, on average, between 150 and 200 workers are killed and more than 100,000 are injured as a result of falls at construction sites.

OSHA recognizes that accidents involving falls are generally complex events frequently involving a variety of factors. Consequently the standard for fall protection deals with both the human and equipment-related issues in protecting workers from fall hazards." The booklet provides guidance for employers and employees to follow when protection is required and discusses how to select fall protection systems. To obtain a copy of the Safety & Health Note call (301) 916-4444. To obtain a copy of the OSHA booklet, contact the local regional or area OSHA office (listed in the telephone directory under U.S. Department of Labor) or write to OSHA Publications Office, 200 Constitution Ave., NW, Room N-3101, Washington, DC 20210.

OSHA regulation 29 CFR 1926.501, "Duty To Have Fall Protection," requires employees, except for those involved in "steel erection," to determine that walking/working surfaces have the strength and structural integrity to safely support them. The regulation further states that each employee on a walking/working surface with an unprotected side or edge that is 6 feet or more above a lower level must be protected from falling by guardrail systems, safety net systems, or personal fall arrest systems.

OSHA regulation 29 CFR 1926.502, "Fall Protection Systems Criteria and Practices," requires employers to provide and install fall protection systems for employees and to comply with all other pertinent requirements before employees begin work that necessitates the fall protection. Covers for holes in floors, roofs, and other walking/working surfaces shall meet the following requirements.

- All covers shall be capable of supporting, without failure, at least twice the weight of employees, equipment, and materials that may be imposed on the cover at any one time.
- All covers shall be secured when installed so as to prevent accidental displacement by the wind, equipment, or employees.
- All covers shall be color-coded or they shall be marked with the word "HOLE" or "COVER" to provide warning of the hazard (except for manhole covers or steel grates).

OSHA regulations can be found at URL http://www.osha-slc.gov/.

DOE facility managers should review requirements and procedures to ensure that employees are familiar with both site and OSHA requirements regarding fall protection when performing work on roofs, towers, stacks, and buildings.

KEYWORDS: construction, fall protection, roof, injury

FUNCTIONAL AREAS: Construction, Industrial Safety

5. LOAD EXCEEDS POSTED RATING OF HOIST

On October 27, 1997, at the Oak Ridge National Laboratory, the facility manager for the High Flux Isotope Reactor reported that millwrights lifted a pressurizer pump motor that exceeded the posted load rating on a monorail hoist. The millwrights did not know the weight of the motor when they performed the lift. Drawings indicated that the motor weighed approximately 3,000 pounds; the monorail and hoist had an assigned capacity of 1 ton. Although the millwrights encountered no problems during the lift, a dropped motor could have resulted in equipment damage or personnel injury. (ORPS Report ORO--ORNL-X10HFIR-1997-0018)

On October 8, 1997, millwrights lifted the pressurizer pump motor with a monorail and hoist and moved it to a location where riggers could lift the motor through a hatchway using a larger crane. The motor was no longer required because both pressurizer pumps had been replaced with newer models. When the riggers arrived, they asked how the millwrights had moved the motor because they knew the approximate weight of the motor when they selected a portable crane. Engineers evaluated the equipment to determine if any damage was done while lifting the motor. They determined nothing had been damaged and returned the hoist and monorail to service.

Investigators determined that the work package did not provide information on the weight of the motor. They determined that millwrights had used the hoist and monorail in the past to perform equipment lifts for pressurizer pump maintenance and replacement. Investigators continue to investigate to determine the root cause of this event and establish corrective actions.

NFS has reported the following events where loads exceeded lifting equipment capacities in the Weekly Summary.

- Weekly Summary 96-48 reported that a rigging crew at Hanford lifted a tank that exceeded the maximum rated capacity of the auxiliary hook on a 40-ton crane. The field superintendent calculated the weight of the tank to be 4,000 pounds; the actual weight was 15,700 pounds. The cable separated from its assembly, and the tank dropped 2 inches to the ground. (ORPS Report Rl-BHI-NREACTOR-1996-0017 and Lessons Learned List Server 1996-RL-FDH-0058)

- Weekly Summary 96-31 reported that during post-maintenance testing of a 10-ton crane at Hanford, testers used a concrete block that was calculated to weigh 16,800 pounds, but actually weighed 24,750 pounds. No one was injured, and the equipment was not damaged. The facility manager suspended use of the crane. (ORPS Report RL--WHC-TPLANT-1996-0012)

- Weekly Summary 96-14 reported that a crane operator at Hanford misread a load cell and lifted an overpack attached to a fuel cask to approximately 5,000 pounds instead of the 1,500-pounds required by procedure. (ORPS Report RL--WHC-FFTF-1996-0003)

- Weekly Summary 96-07 reported that a crane operator at Argonne National Laboratory—West used the wrong capacity sling to rig and hoist a transfer cask shield ring. The load was more than double the sling capacity. The rated capacity for the sling was 2,500 pounds, and the shield ring weighed 5,200 pounds. Investigators determined that the crane operator failed to check the load weight and capacity of the rigging before performing the lift. (ORPS Report CH--AA-ANLW-HFEF-1996-0001)

These events illustrate the importance of ensuring that the load does not exceed the rated capacity of the hoist or rigging equipment. Dropped loads can be extremely hazardous. DOE-STD-1090-96 (rev 1), *Hoisting and Rigging*, provides guidance for hoisting and rigging and identifies related codes, standards, and regulations. The following guidance applies to this event.

- Section 3.2.4, “Equipment/Rigging Selection,” recommends determining the type, class, and minimum capacity of lifting equipment (hoist, crane, forklift, etc.) required for the operation based on the identified load, task, and hazards.

- Section 8.5.2, “Size of Load,” requires that personnel know the weight of the load and do not load the hoist beyond the rated capacity, except as provided for in section 8.3, “Testing.”

- Section 8.5.6, “Ordinary Lifts,” states that a designated leader shall ensure that the weight of the load is determined, that proper equipment and accessories are selected, and that the rated capacity of the hoist is not exceeded.

KEYWORDS: hoisting and rigging, motor, lift, dropped load

FUNCTIONAL AREAS: Hoisting and Rigging, Industrial Safety

6. INADEQUATE WORK CONTROLS FOR EXCAVATION ACTIVITIES

This week OEAF engineers reviewed three occurrence reports about inadequate work controls and pre-job planning during excavation activities. On October 22, 1997, at the Hanford Site, a plant maintenance worker received a slight shock from a heat-traced line while excavating a potable water line. Investigators determined that the workers knew the heat-tracing was present. However, they did not lock or tag out the line because they did not expect to contact it. On October 23, 1997, at the Idaho National Engineering Environmental Laboratory, a construction worker struck and damaged an energized 480-volt cable with a backhoe, interrupting power to three buildings. Investigators determined that procedural violations and communication errors contributed to this event. On October 27, 1997, at the National Institute for Petroleum and Energy Research, a construction worker severed a natural gas line with a trenching machine, resulting in evacuation of the area. Investigators determined that as-built drawings incorrectly identified the line depth. Inadequate procedural controls and communications resulted in equipment damage, a worker receiving a shock, and endangered lives. (ORPS Reports RL--PHMC-KBASINS-1997-0023, ID--LITC-LANDLORD-1997-0017 and HQ--GOPE-NIPER-1997-0005)

On October 22, 1997, at Hanford, two plant maintenance workers were hand-excavating near a potable water line when they contacted heat-tracing that extended underground and into the area being excavated. While removing dirt from around a stand pipe, the workers wedged a shovel under it, rocked it to free the surrounding earth, and accidentally cut the heat-trace. The worker was shocked because he was touching the metal stand pipe when the shovel cut the heat-trace. The workers did not expect to be near energized electrical lines so they were not wearing protective clothing. The facility manager held a critique and is continuing to develop and implement corrective actions.

On October 23, 1997, at the Idaho National Engineering Environmental Laboratory, a backhoe struck and damaged a 480-volt cable while excavating for a plant-wide utilities upgrade. The backhoe penetrated the conduit and pulled the cable loose from an electrical supply breaker. The breaker tripped on ground-fault protection and caused a loss of power to three buildings. Investigators determined that the breaker trip protected the subcontractor. Construction personnel stopped excavations and isolated the damaged cable. The facility manager placed all excavations on hold until corrective actions can be determined and implemented. Investigators determined that an earlier excavation area was re-opened for the second phase of the project so workers could install a shallow communications duct bank. The work site was adjacent to a deeper high-voltage duct bank installed during an earlier phase of the project. Construction personnel had not restored the sub-surface cable locations markings they had previously used, and no one performed a new sub-surface investigation as required by procedures. The facility manager held a critique and determined that the following procedural violations contributed to this event.

- The subcontractor project superintendent knew where the cable was located, but he did not tell the backhoe operator because he believed that the cable was deeper than the projected depth of the excavation activity for the shallow duct bank.

- Construction personnel who were aware of the cable location did not mention it in the pre-job briefing.

- Construction personnel did not use a construction management checklist to review preparations for excavations because the checklist was developed after the work was approved.

On October 27, 1997, a subcontractor at the National Institute for Petroleum and Energy Research ruptured a 2.5-inch natural gas utility line while digging a trench for an electrical installation. The facility manager ordered an immediate evacuation of the area and adjacent buildings. Facility personnel and the local fire department secured gas flow and isolated the line. Facility personnel are developing corrective actions, including requiring a walk-down of excavation areas before each job and implementing a dig permit program. Investigators reported that this is the third gas line ruptured during excavation activities this year. On July 14, personnel hit and ruptured a 1-inch natural gas line, at a 3-inch junction with a main line, during excavation work. On October 2, a contractor ruptured a 3-inch natural gas line while demolishing a building. Investigators determined that construction drawings did not show the correct location for the line. The facility manager directed investigators to perform a Type C investigation for the two most recent events because of the frequency of repeat occurrences. Figure 6-1 shows a 1989 event at Lebanon, Missouri, where an operator was killed when the road grader he was using struck a 10-inch propane pipeline.

Figure 6-1. Propane Line Severed[1]

1 *Underground Focus*, (Canterbury Communications, P.O. Box 638, Spooner, WI 54801. Internet-http://www.underspace.com)

NFS has reported events where workers severed or contacted conduits or cables during construction activities in several Weekly Summaries. Following are some examples.

- Weekly Summary 97-35 reported that a construction worker at the Idaho National Engineering Environmental Laboratory cut an energized 480-volt line while saw-cutting a concrete floor. (ORPS Report ID--LITC-SMC-1997-0005)

- Weekly Summary 97-33 reported four events about severed underground electrical and telephone lines. All of the events occurred on August 7 and 8, 1997. (ORPS Reports RL--PHMC-WESF-1997-0007, RL--PNNL-PNNLBOPER-1997-0023, and SAN--LLNL-LLNL-1997-0051)

- Weekly Summaries 96-04 and 96-05 reported that a mason tender at Los Alamos National Laboratory received a severe electrical shock that resulted in serious burns and cardiac arrest. The mason tender was excavating in a building basement when the jackhammer he was operating contacted an energized 13.2-kV electrical cable. (Type A Accident Investigation Board Report on the January 17, 1996, Electrical Accident with Injury in Building 209, Technical Area 21 Los Alamos National Laboratory; ORPS Report ALO-LA-LANL-TSF-1996-0001)

These events underscore the importance of using effective work control practices and detailed pre-job planning. In the Hanford event, failure to lock or tag out the heat-tracing led to a worker being shocked. In the Idaho event, personnel reviewed drawings, performed line location surveys, and located the line before work began on the first phase of the project. However, failure to communicate and follow procedures endangered the backhoe operator during the second phase of the project. In the National Institute for Petroleum and Energy Research event there were indications that drawings were inaccurate and pre-construction walk-downs were not effective in preventing recurrences. Safety and health hazard analysis must be included in the work control process to help prevent worker injury. Pre-job briefings, facility procedures, and training programs should emphasize the dangers associated with excavation activities. Many events have occurred while personnel were digging, trenching, or drilling.

Lockout/tagout programs in DOE serve two functions. The first function, defined in both 29 CFR 1910, *Occupational Safety and Health Standards*, and DOE O 5480.19, *Conduct of Operations Requirements for DOE Facilities,* is to protect personnel from injury and protect equipment from damage. The second function is to provide overall control of equipment and system status. Lockout/tagouts are typically applied during maintenance activities; however, there are many cases when lockout/tagouts are needed for personnel safety. The standard states that an effective lockout/tagout program requires three elements. These elements are as follows: (1) all affected personnel must understand the program; (2) the program must be applied uniformly in every job; and (3) the program must be respected by every worker and supervisor. A good lockout/tagout program is an important element of an effective conduct of operations program.

DOE facility managers should ensure that personnel understand the basics of work control practices, work planning, and safety and health hazard analysis. Many references apply to these events. Following are some examples that facility managers should review to ensure they are incorporated in current facility safety programs.

- DOE O 5480.19 states that DOE policy is to operate DOE facilities in a manner to ensure an acceptable level of safety and that procedures are in place to control conduct of operations. Chapter VIII, “Control of Equipment and System Status,” provides an overall perspective on control of equipment and system status. Specific applications of system control are addressed in chapter IX, “Lockout/Tagout,” and chapter X, “Independent Verification.”

- DOE-STD-1030-96, *Guide to Good Practices for Lockouts and Tagouts*, provides guidance on lockout/tagout program implementation and management at DOE facilities.

- OSHA 29 CFR 1926, *Safety and Health Regulations for Construction,* sub-parts .651(b) and .416(a)(3) assign employers responsibility for identifying underground hazards and energized circuits near the work area. The requirements of 29 CFR 1926.965(c) state that work must be conducted in a manner to avoid damage to underground facilities. Similarly, work must be performed in a manner that provides protection to the workers.

- *Construction Safety Reference Guide*, section B.8, discusses requirements for a lockout/tagout program for construction activities. This section of the guide endorses OSHA regulations contained in 29 CFR 1910.147, "The Control of Hazardous Energy (Lockout/Tagout)," and indicates where OSHA training requirements are mandatory.

NFS has prepared and issued three documents that provide guidance related to these events. DOE facility representatives, manager, and personnel responsible for construction safety programs may want to review these documents to assist in implementing effective programs.

DOE/EH-0540, Safety Notice No. 96-05, "Lockout/Tagout Programs," summarizes lockout/tagout events at DOE facilities, provides lessons learned and recommended practices, and identifies lockout/tagout program requirements.

The *Hazard and Barrier Analysis Guide*, developed by OEAF, includes a hazard-barrier matrix that shows that lockout/tagout is the most effective barrier against injury. When implemented properly, lockout/tagout provides a high probability (greater than 99 percent) of success for risk reduction.

DOE/EH-0541, Safety Notice 96-06, "Underground Utilities Detection and Excavation," provides descriptions of recent events, an overview of current technology for underground utility detection, specific recommendations for improving site utilities detection and excavation programs, and information on innovative practices used at DOE facilities. The notice states that a central coordinator should not only assist in identifying underground utilities, but should also record the findings.

Safety Notices 96-05 and 96-06 can be obtained by contacting the ES&H Information Center, (301) 903-0449, or by writing to ES&H Information Center, U.S. Department of Energy, EH-72/Suite 100, CXXI/3, Germantown, MD 20874. Safety Notices are also available on the OEAF Home Page at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ons.html. A copy of the *Hazard and Barrier Analysis Guide* is available from Jim Snell, (301) 903-4094, and may also be obtained by contacting the ES&H Information Center, (301) 903-0449, or by writing to ES&H Information Center, U.S. Department of Energy, EH-72/Suite 100, CXXI/3, Germantown, MD 20874.

KEYWORDS: construction, electrical, gas line, excavation

FUNCTIONAL AREAS: Industrial Safety, Hazards Analysis, Work Planning

FINAL REPORT

1. DE-ENERGIZATION OF MULTIPLEXOR CABINET IMPACTS OPERATIONAL SAFETY REQUIREMENT INSTRUMENTATION

This week OEAF engineers reviewed a final occurrence report about the loss of instrumentation credited by the facility Operational Safety Requirement (OSR) during the de-energization of a multiplexor cabinet at the Savannah River In-Tank Processing Facility. On September 8, 1997, electrical and instrumentation technicians locked out the multiplexor cabinet causing a loss of some nitrogen tank level instrumentation. Operators received several distributed control system software alarms in the control room, but they received no hardwired panel alarms (generally credited by the OSR) alerting them to the loss of the level instrumentation. Control room operators investigated the distributed control system software alarms and discovered that the OSR-credited level instrumentation was lost. They immediately entered the appropriate limiting condition for operations. The shift manager directed operators to re-energize the multiplexor cabinet to restore the level indications. Investigators determined that system drawings did not reflect the as-built configuration of the distributed control system. Failure to control and understand the system configuration resulted in the loss of instrumentation important to safety. (ORPS Reports SR--WSRC-ITP-1997-0026)

On September 10, following the investigation of the September 8 event, the facility manager reported that the same instrumentation was also lost on August 25 when technicians de-energized the cabinet as part of a pre-lockout check to determine what equipment would be affected. Facility personnel did not adequately investigate the cause of the August 25 software alarms; therefore, they did not know about the loss of the level instrumentation. Logbook entries showed no indication that anyone had entered the appropriate limiting condition for operation. Although no OSR violation occurred, the failure to recognize the loss of OSR-required instrumentation resulted in a reoccurrence of the event 2 weeks later. (ORPS Reports SR--WSRC-ITP-1997-0027)

The multiplexor cabinet is part of a distributed control system that will be upgraded with a newer version. Engineers developed a system checkout plan to identify what equipment could be affected when the multiplexor cabinet was de-energized for the upgrade. Known weaknesses in configuration control of the distributed control system warranted development of the checkout plan.

The facility manager conducted a critique of the event. Critique members determined that during the August 25 event operators should have checked the status of local tank level instrumentation when they received the distributed control system alarms in the control room. Operators typically relied on hardwired alarms because most of the OSR-required equipment is stand-alone from the distributed control system. Critique members also determined that the power source to the multiplexor cabinet also provided power to the OSR-required local tank level instruments that input to the distributed control system. The installation of the new version of the distributed control system will be performed with more stringent controls of the system configuration.

Investigators determined that a design problem (drawing, specification, or data errors) was both the direct and root cause of the event. The drawings had not been field-verified and contained information that was difficult to understand or inaccurate. They also determined the contributing cause was a training deficiency (insufficient practice or hands-on experience). The engineer who reviewed the lockout was not the cognizant engineer and did not have sufficient integrated knowledge to adequately perform the review with the material provided. Therefore, the engineer was not aware that the level instrumentation was powered through the multiplexor cabinet and that de-energizing it would result in the loss of these instruments. Facility personnel will perform the following corrective actions.

- Prepare a list of OSR-credited instruments in the facility and provide the list to personnel who review work packages and lockouts.

- Review alarms to ensure consistency with limiting conditions for operations.
- Establish drawings for configuration control of the multiplexor cabinets.
- Institute a policy requiring that only cognizant engineers, or engineers with sufficient integrated knowledge, review critical lockouts and work packages.

NFS reported configuration management issues in Weekly Summaries 96-26 and 96-28.

- Weekly Summary 96-26 reported that electricians at the Hanford Site installed personal locking devices to de-energize four cooling fans in a bank of eight, and two of the four fans started automatically from a thermostat. The electricians thought their locking device de-energized the two fans that started. Mislabeled equipment and system operation without field-verified drawings resulted in the near miss. (ORPS Report RL--WHC-TANKFARM-1996-0041)
- Weekly Summary 96-28 reported two events at the Savannah River Site caused by inaccurate drawings. At the In-Tank Processing Facility, electricians observed arcing when they cut an electrical cable they believed to be de-energized. The electricians used inaccurate drawings when de-energizing the cables. At F-Canyon, operators detected contamination in a process water system after an incorrect water supply valve was opened. Operators used an inaccurate sketch included in their procedure. (ORPS Reports SR--WSRC-ITP-1996-0013 and SR--WSRC-FCAN-1996-0004)

These events underscore the importance of maintaining a stringent configuration management program. Configuration control is important to ensure safe operation, testing, and maintenance of facility equipment and systems. If operations personnel, engineers, and technicians had thoroughly understood the as-built configuration of the distributed control system, such as power sources, instrumentation, and system interfaces, these events could have been prevented.

DOE-STD-1073-Pt.1 and -Pt.2, *Guide for Operational Configuration Management Program*, states that physical configuration assessments or walk-downs should be performed for representative sample structures, systems, and components within the facility to determine the degree of agreement between the physical configuration and the configuration on the facility documentation. Physical walk-downs should be included as part of the programmatic assessments conducted during initial assessments, post-implementation assessments, and periodic effectiveness assessments. Facility managers should verify that these assessments including electrical drawings and system configuration as well as mechanical system drawings.

KEYWORDS: operational safety requirement, instrumentation, configuration control, limiting conditions for operations, training and qualifications

FUNCTIONAL AREAS: Configuration Control, Licensing/Compliance, Operations, Training and Qualifications